INDICATOR | Sulfur Dioxide Emissions

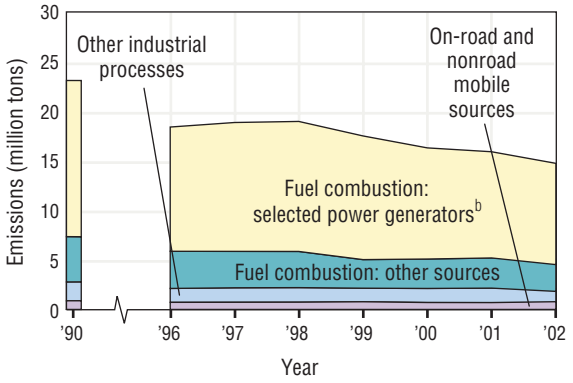
Sulfur dioxide (SO_2) belongs to the family of sulfur oxide (SO_x) gases. These gases are formed when fuel containing sulfur (mainly coal and oil) is burned (e.g., for electricity generation) and during metal smelting and other industrial processes. High concentrations of SO_2 are associated with multiple health and environmental effects (U.S. EPA, 2003). The highest concentrations of SO_2 have been recorded in the vicinity of large industrial facilities. Although relatively few people live in areas where SO_2 concentrations exceed the National Ambient Air Quality Standards (NAAQS), SO_2 emissions are an important environmental issue because they are a major precursor to ambient $PM_{2.5}$ concentrations: many more people live in $PM_{2.5}$ non-attainment areas, which has several documented human health and ecological effects (the PM Concentrations indicator).

Health effects associated with SO_2 depend on the exposure concentrations and durations, and on the susceptibility of exposed populations. Asthmatics are much more susceptible to SO_2 exposure than people who do not have asthma (U.S. EPA, 1986). Effects associated with longer-term exposures to high concentrations of SO_2, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs' defenses, and aggravation of existing heart or lung disease. The most susceptible populations under these conditions include individuals with cardiovascular disease or chronic lung disease, children, and older adults (U.S. EPA, 1982).

Many other environmental concerns are associated with high concentrations of SO_2. For example, airborne SO_2, along with NO_x, contributes to acidic deposition (the Acid Deposition indicator); SO_2 is a major precursor to $PM_{2.5}$ (the PM Concentrations indicator); and SO_2 contributes to impaired visibility (the Regional Haze indicator). SO_2 exposure also can harm vegetation by increasing foliar injury, decreasing plant growth and yield, and decreasing the number and variety of plant species in a given community. Finally, SO_2 can accelerate the corrosion of materials (e.g., concrete, limestone) that are used in buildings, statues, and monuments that are part of the nation's cultural heritage (U.S. EPA, 1982).

This indicator presents SO_2 emissions from traditionally inventoried anthropogenic source categories: (1) "Fuel combustion: selected power generators," which includes emissions from coal-, gas-, and oil-fired power plants that are required to use continuous emissions monitors (CEMs) to report emissions as part of the Acid Rain Program (ARP); (2) "Fuel combustion: other sources," which includes industrial, commercial, and institutional sources, as well as residential heaters and boilers not required to use CEMs; (3) "Other industrial processes," which includes chemical production and petroleum refining; (4) "On-road vehicles," which includes cars, trucks, buses, and motorcycles; (5) "Nonroad vehicles and engines," which include farm and construction equipment, lawnmowers, chainsaws, boats, ships, snowmobiles, aircraft, and others. Because a substantial portion of airborne SO_2 comes from fossil fuel combustion in electric utilities, this indicator includes the separate "Fuel combustion: selected power generators" category in addition to the four categories presented in the other emissions indicators.

Exhibit 2-27. SO_2 emissions in the U.S. by source category, 1990 and 1996-2002[a]



[a]Data are presented for 1990 and 1996-2002, as datasets from these inventory years are fully up to date. Data are available for inventory years 1991-1995, but these data have not been updated to allow comparison with data from 1990 and 1996-2002.

[b]This category includes emissions from only those power plants required to use continuous emissions monitors under the Acid Rain Program.

Data source: *U.S. EPA, 2007b*

SO_2 emissions data are tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. For major electricity generating units, most data come from CEMs that measure actual emissions. For other fuel combustion sources and industrial processes, data are estimated using emission factors. Emissions from on-road and nonroad sources were estimated using EPA-approved modeling approaches (U.S. EPA, 2007a).

NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally recognized American Indian nations. Data are presented only for 1990 and from 1996 to 2002; prior to 1996, only the 1990 data have been updated to be comparable to the more recent inventories.

What the Data Show

National estimated SO_2 emissions decreased 37 percent between 1990 and 2002 (from 23,064,000 to 14,639,000 tons) (Exhibit 2-27). This downward trend resulted primarily from emissions reductions at electric utilities. Between 1990 and 2002, air emissions from electric utilities have consistently accounted for roughly two-thirds of the nationwide SO_2 emissions.

Net SO_2 emissions declined in all EPA Regions between 1990 and 2002 (Exhibit 2-28). During this time frame, the largest percent reductions in SO_2 emissions were seen in Regions 1 (59 percent), 2 (49 percent), and 5 (48 percent), and the smallest reductions were observed in Regions 6 (15 percent) and 9 (18 percent).

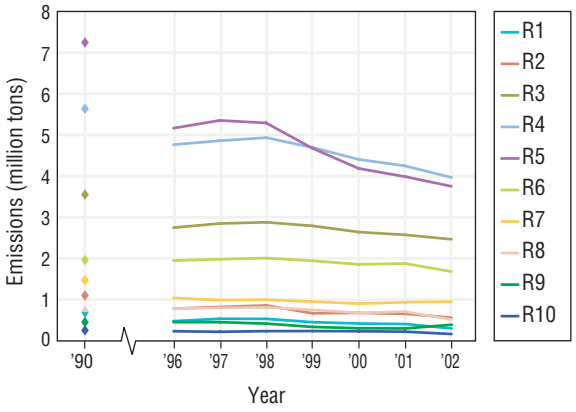
Indicator Limitations

- Though emissions from most electric utilities are measured directly using continuous monitoring devices, SO_2 emissions data for other source types are based on estimates that employ emission factors generated from empirical and engineering studies. Although these estimates are generated using well-established approaches, the estimates have uncertainties inherent in the emission factors and emissions models used to represent sources for which emissions have not been directly measured.
- Comparable SO_2 emissions estimates through the NEI are available only for 1990 and 1996-2002. Data for 1991-1995 are not provided due to differences in emissions estimation methodologies from other inventory years, which could lead to improper trend assessments.
- SO_2 emissions from "miscellaneous sources" are not included in the total emissions. Details on emissions from miscellaneous sources can be found by downloading 2002 NEI inventory data for the "nonpoint sector" (http://www.epa.gov/ttn/chief/net/2002inventory.html).
- The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data prior to these revisions must be considered in the context of those changes.
- Not all states and local agencies provide the same data or level of detail for a given year.

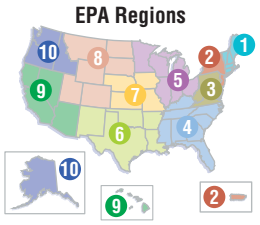
Data Sources

Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on SO_2 emissions data in the NEI (U.S. EPA, 2007b) (http://www.epa.gov/ttn/chief/net/2002inventory.html). This indicator aggregates the NEI data by source category and EPA Region.

Exhibit 2-28. SO_2 emissions in the U.S. by EPA Region, 1990 and 1996-2002[a]



[a]Data are presented for 1990 and 1996-2002, as datasets from these inventory years are fully up to date. Data are available for inventory years 1991-1995, but these data have not been updated to allow comparison with data from 1990 and 1996-2002.



Data source: *U.S. EPA, 2007b*

References

U.S. EPA (United States Environmental Protection Agency). 2007a. Documentation for the final 2002 mobile National Emissions Inventory, Version 3. <ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/mobile/2002_mobile_nei_version_3_report_092807.pdf>

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